

Advance Power System Trainers

The use of power electronics in power system control and power quality improvements has increased extensively. Power electronics control greatly help in maintaining power quality, voltage and frequency values. Reactive power support, voltage control, power factor control using Thyristorised and IGBT based arrangement are developed.

NITech offers a wide range of advance power electronics converter kits for studying application of power electronics in power system. Kits for static var control (SVC), HVDC, STATCOM, DVR and harmonic elimination are also designed.



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A way to Power Electronics and Embedded Systems Solutions...

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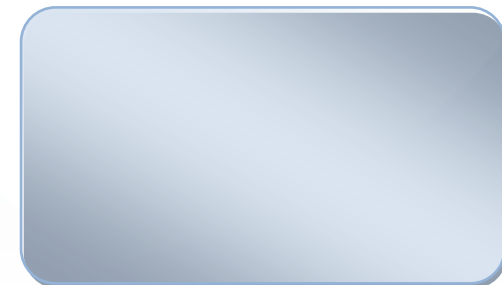
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NIAPS01 Single Phase Thyristor Controlled Reactor

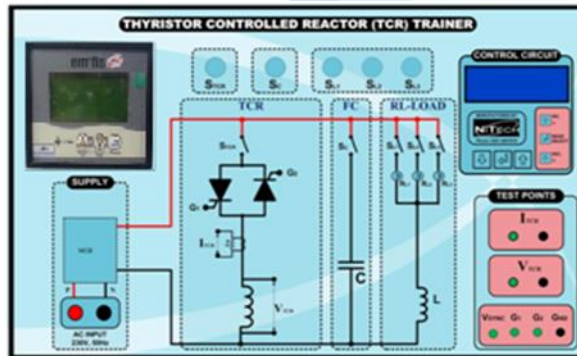
Trainer for studying working principle of single phase fixed capacitor thyristor controlled reactor (FC-TCR).

The kit includes:

- ❖ Microcontroller based gate pulse generation circuit.
- ❖ Panel for demonstrating TCR and FC-TCR principal
- ❖ Variable reactive load with fixed inductance and variable resistance.
- ❖ Single phase fix capacitor which compensate full load reactive power.
- ❖ Reactor with Thyristor controlled branch.
- ❖ Auto / Manual mode of operation
- ❖ Measuring of reactive power in different load conditions.
- ❖ 01 CT and 01 PT to observe isolated current and voltage waveforms.
- ❖ Observation of intermediate stage waveforms of gate pulse generation.
- ❖ Power meter for measuring reactive power and other parameters.

Specifications:

- ❖ Supply Voltage: 230 V, 50 Hz.
- ❖ Variable R-L load with switching mechanism. (Three Bulbs and One Inductor)
- ❖ One Capacitor Bank
- ❖ TCR branch with back to back Thyristors and inductor
- ❖ 1:1000 A CT and 230:6 V PT for isolated observation of voltage and current waveforms.
- ❖ Multi-parameter meter (Elmeasure) for measuring power supply current THD and other parameters.
- ❖ SST89E516RD MCU @18.432MHz based digital gate pulse generation circuit.



The setup will consist of following cards:

1. Controller Card:

- ❖ SST89E516RD 8-bit MCU clocked @18.432MHz
- ❖ Buffered I/O Ports using 74HC573
- ❖ 5 Interface Keys
- ❖ 16x2 LCD (JHD162A) display
- ❖ UART section (IC Max 232)

2. Thyristor firing card:

- ❖ +ZCD and -ZCD using diodes
- ❖ on board 5 kHz carrier using RC circuit
- ❖ Pulse Transformer based driving
- ❖ Gate resistor with anti-parallel diode

3. Power card:

- ❖ Thyristor 25TT12 (25A, 1200V) (3 Nos.)
- ❖ Diode 1N5408 (1 Nos.)
- ❖ Snubber circuit

List of Experiments:

- ❖ Measurement of active and reactive power of the load.
- ❖ Compensation of reactive power with fixed capacitor.
- ❖ Study of Thyristor Controlled Reactor (TCR) operation.
- ❖ Study of reactive power compensation with TCR in open loop.
- ❖ Compensation with TCR in close loop

NIAPS02 Single Phase Thyristor Switched Capacitor

Trainer for studying working principle of single phase thyristor switched capacitor (TSC).

Specifications:

- ❖ Microcontroller based gate pulse generation circuit.
- ❖ Observation of intermediate stage waveforms of gate pulse generation.
- ❖ Panel for demonstrating TSC principal.
- ❖ Variable reactive load with fixed inductance and variable resistance.
- ❖ Power meter for measuring reactive power and other parameters.
- ❖ 3 numbers of thyristor controlled single phase capacitor bank.
- ❖ Two configurations of thyristor AC switch :
 - Thyristor -Thyristor configuration
 - Thyristor -Diode configuration
- ❖ Measuring of reactive power in different load conditions.
- ❖ Auto / Manual Operation

The setup will consist of following cards:

1. Controller Card:

- ❖ SST89E516RD 8-bit MCU clocked @18.432MHz
- ❖ Buffered I/O Ports using 74HC573
- ❖ 5 Interface Keys
- ❖ 16x2 LCD (JHD162A) display
- ❖ UART section (IC Max 232)

2. Thyristor firing card:

- ❖ +ZCD and -ZCD using diodes
- ❖ on board 5 kHz carrier using RC circuit

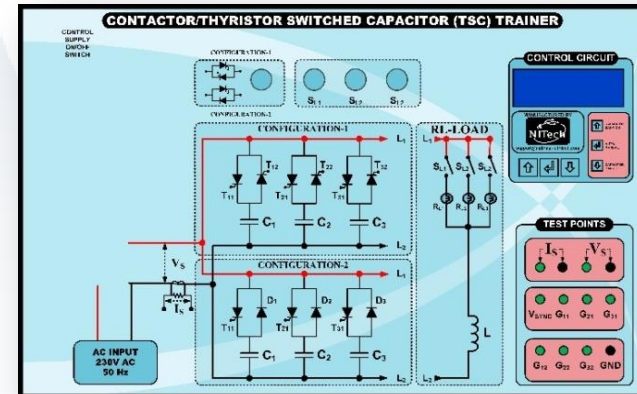
- ❖ Pulse Transformer based driving
- ❖ Gate resistor with anti-parallel diode

3. Power card:

- ❖ Thyristor 25TT12 (25A, 1200V)
- ❖ Diode 1N5408 (03 Nos.)
- ❖ Snubber circuit

List of Experiments:

- ❖ Measurement of active and reactive power of the load.
- ❖ Compensation of reactive power with fixed capacitor.
- ❖ Study of reactive power compensation with TSC in open loop.
- ❖ Study of reactive power compensation with TSC in closed loop.



NIAPS03 Three Phase Thyristor Controlled Reactor

Trainer for studying three-phase Thyristor Controlled Reactor working with fixed capacitor (FC-TCR).

Specifications:

- ❖ Microcontroller based gate pulse generation circuit.
- ❖ Observation of intermediate stage waveforms of gate pulse generation.
- ❖ Panel for demonstrating TCR and FC-TCR principle.
- ❖ Power meter for measuring reactive power and other parameters.
- ❖ 1 kVAR three phase delta connected fix capacitor bank.
- ❖ Three phase Reactor with Thyristor controlled switch.
- ❖ Auto / Manual mode of operation.
- ❖ Measuring of reactive power in different load conditions.
- ❖ 01 CT and 01 PT for isolated current and voltage waveform observations.

The setup will consist of following cards:

1. Controller Card:

- ❖ SST89E516RD 8-bit MCU clocked @18.432MHz
- ❖ Buffered I/O Ports using 74HC573
- ❖ 5 Interface Keys
- ❖ 16x2 LCD (JHD162A) display
- ❖ UART section (IC Max 232)

2. Thyristor firing card:

- ❖ +ZCD and -ZCD using diodes
- ❖ on board 5 kHz carrier using RC circuit
- ❖ Pulse Transformer based driving
- ❖ Gate resistor with anti-parallel diode

3. Power card:

- ❖ Rating: 300V, 5A
- ❖ Thyristor 25TT12 (25A, 1200V)
- ❖ Snubber circuit

List of Experiments:

- ❖ Measurement of active and reactive power of the load.
- ❖ Compensation of reactive power with fixed capacitor.
- ❖ Study of reactive power compensation with TSC in open loop.
Study of reactive power compensation with TSC in closed loop



NIAPS04 Three Phase Thyristor Switched Capacitor

Trainer for studying three-phase Thyristor Switched Capacitor (TSC) operation.

Specification:

- ❖ Microcontroller based gate pulse generation circuit.
- ❖ Observation of intermediate stage waveforms of gate pulse generation.
- ❖ Panel for demonstrating TSC principle.
- ❖ Power meter is for measuring reactive power and other parameters.
- ❖ 3 banks of thyristor switched capacitor with matching reactive load.
- ❖ AC switch (thyristor-diode) for connecting and disconnecting capacitor banks.
- ❖ Auto / Manual Operation.
- ❖ Measuring of reactive power in different load conditions.
- ❖ 01 CT and 01 PT for isolated current and voltage waveform observations.
- ❖ Principle of TSC is fully demonstrated with this trainer.

The setup will consist of following cards:

1. Controller Card:

- ❖ SST89E516RD 8-bit MCU clocked @18.432MHz
- ❖ Buffered I/O Ports using 74HC573
- ❖ 5 Interface Keys
- ❖ 16x2 LCD (JHD162A) display
- ❖ UART section (IC Max 232)

2. Thyristor firing card:

- ❖ +ZCD and -ZCD using diodes
- ❖ on board 5 kHz carrier using RC circuit
- ❖ Pulse Transformer based driving
- ❖ Gate resistor with anti-parallel diode

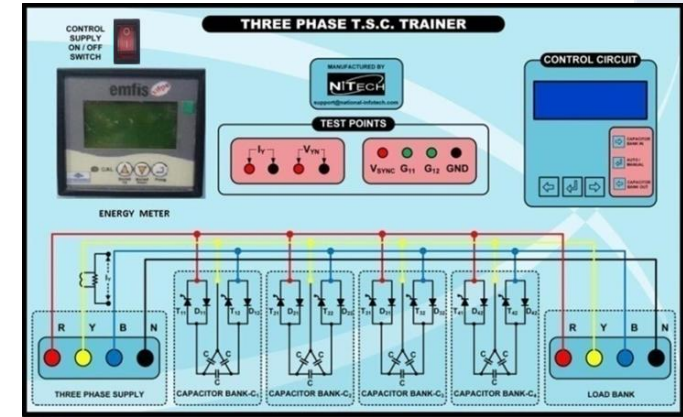
3. Power card:

- ❖ Rating: 300V, 5A
- ❖ Thyristor 25TT12 (25A, 1200V)
- ❖ Diode 1N5408 (06 Nos.)
- ❖ Snubber circuit

List of Experiments:

- ❖ Measurement of active and reactive power of the load.
- ❖ Compensation of reactive power with fixed capacitor.
- ❖ Study of Thyristor Controlled Reactor (TCR) operation.
- ❖ Study of reactive power compensation with TCR in open loop.

- ❖ Study of reactive power compensation with TCR in close loop.



NIAPS05 Tuned Harmonic Passive Filter

Trainer for studying tuned harmonic shunt passive power filter operation.

The kit includes:

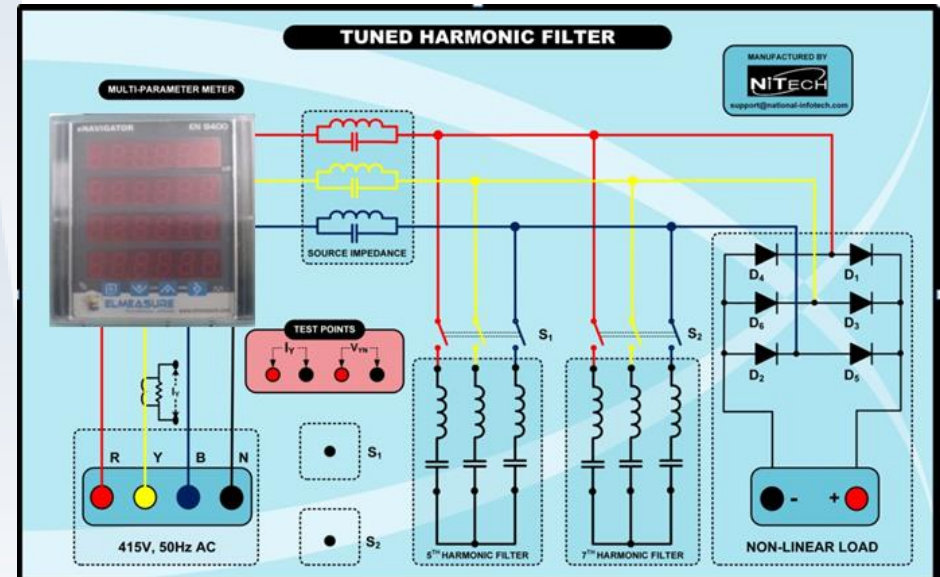
- ❖ Three phase diode rectifier with R-load as harmonic producing load.
- ❖ Three phase 5thharmonic L-C tuned filter branch
- ❖ Three phase 7thharmonic L-C tuned filter branch
- ❖ Multi-parameter meter for observing supply current THD in different conditions.
- ❖ 01 CT and 01 PT for isolated current and voltage waveform observations.

Specifications:

- ❖ Diode rectifier with rating 600 V, 5 A
- ❖ Resistive Load bank 1 kW
- ❖ Three phase 5thharmonic tuned filter L = 80 mH and C = 5 uF.
- ❖ Three phase 7thharmonic tuned filter L = 80 mH and C = 2.58 uF.
- ❖ Contactor based switching mechanism for connecting and disconnecting 5thand 7thfilter bank in the system.
- ❖ 1:1000A CT and 230:6V PT for isolated observation of voltage and current waveforms.
- ❖ Multi-parameter (Elmeasure) for measuring supply current THD and other parameters.

List of Experiments:

- ❖ Measurement of voltage, current, active power, reactive power and THD of source current with the load.
- ❖ Measurement of voltage, current, active power, reactive power and THD of source current with 5thharmonic tuned filter connected in the system.
- ❖ Measurement of voltage, current, active power, reactive power and THD of source current with 5th and 7thharmonic tuned filter connected in the system.
- ❖ Observation of source current waveform and its harmonic analysis at different stage of compensation.



NIAPS06 Dynamic Voltage Regulator (DVR)

Trainer for studying static voltage regulation using dynamic voltage regulator (DVR).

The kit includes:

- ❖ Load bank up to 1kVA
- ❖ Inverter with series transformer for series voltage injection.
- ❖ Microcontroller base gate pulse generation circuit.
- ❖ Under Voltage, Over Voltage and Over Current protection.
- ❖ Sensing circuit for sensing input, output and injected voltage.

Specifications:

- ❖ Voltage regulation between 170-260V.
- ❖ Output voltage of 220V
- ❖ Series injection transformer (180:60V, 300VA)
- ❖ Inverter for In-phase and out of phase voltage injection (500VA)
- ❖ Resistive Load bank of 1kVA
- ❖ Static voltage stabilizing
- ❖ Soft starting and overload protection

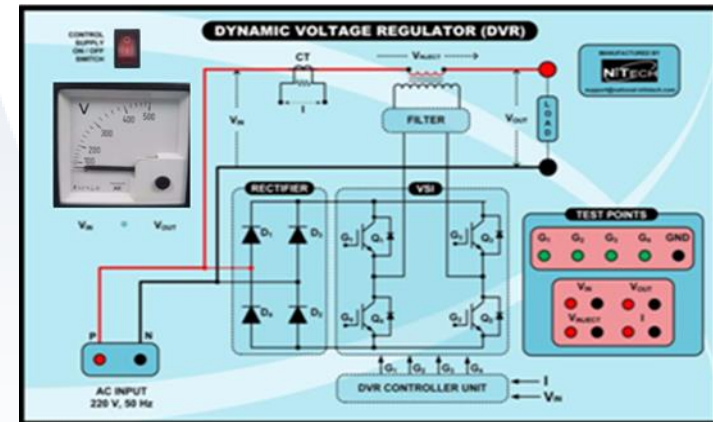
The setup will consist of following cards:

1. 32 bit ARM-Cortex controller card:

- ❖ STM32F407VGT MCU @168MHz
- ❖ Buffered I/O Ports using 74HC573
- ❖ 2 DAC outputs
- ❖ 9 ADC input channels with buffering using LM324 IC
- ❖ On board QEI (Quadrature Encoder Interface) section
- ❖ 5 Keys push to ground
- ❖ 16*2 LCD (JHD162A) display
- ❖ UART section (RS-232)(IC Max 232)

2. IGBT Driver and Power card

- ❖ Suitable for 600V, 25 A IGBTs
- ❖ 2 A rail-to-rail output
- ❖ Input pulses: CMOS 0-5 V or 0-3.3 V (Active high pulse)
- ❖ Output pulses: Isolated +16V/-8V
- ❖ Shoot through, Short circuit protection with DESAT-detection
- ❖ On board hardware dead time generator circuit (1 μ Sec)
- ❖ 06 SMPS for generating +16V/-8V isolated power supplies required for driver IC
- ❖ RESET to start gate pulses after clearing the FAULT. Driver can be RESET via on board switch or external reset pulse.
- ❖ **Power card:** IGBT 25N120ND (25A, 1200V) (08 Nos.)



List of Experiments:

- ❖ Study of Voltage regulation and under voltage cutoff with lower voltages.
- ❖ Study of Voltage regulation and over voltage cutoff with higher voltages
- ❖ Study of Overload protection
- ❖ Study of Soft starting
- ❖ Observation of source voltage, injected voltage and load voltage.
- ❖ Transient performance evaluation of DVR.

NIAPS07 HVDC Trainer with 6 pulse converter

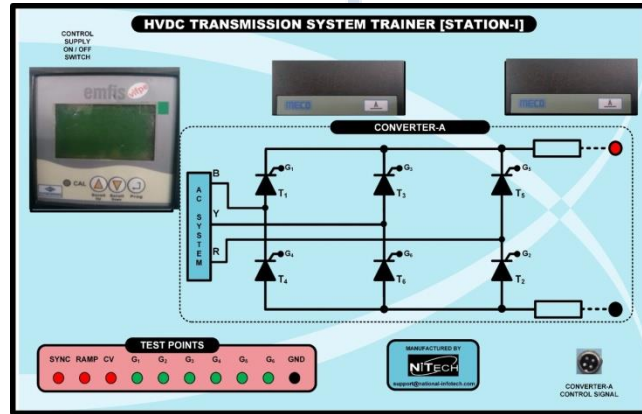
Electrical plants generate power in the form of AC voltages and AC currents. This power is transmitted to the load centers on three phases, AC transmission lines. However, under certain circumstances, it becomes desirable to transmit this power over DC transmission lines. This alternative becomes economically attractive where a large amount of power is to be transmitted over a long distance from a remote generating plant to the load center.

This Trainer is to demonstrate principle operation of HVDC transmission system. The experiment setup consists of converter station and inverter stations, made using six-pulse converters for making bipolar configuration of HVDC.

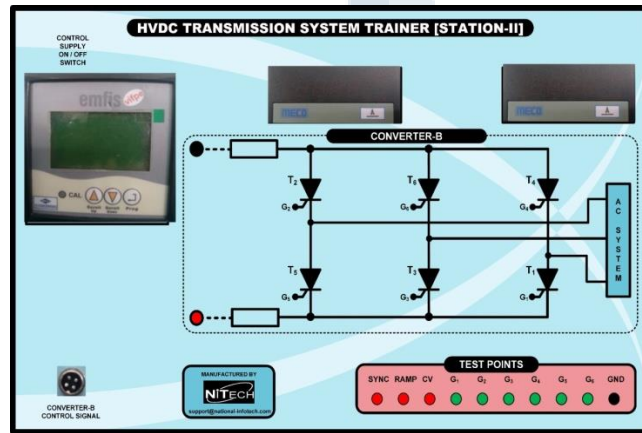
Microcontroller based control circuit along with multi-parameter meter is provided to observe and demonstrate bidirectional flow of power. Test signals for current and voltage waveform observation across different elements are provided.

The pictorial view of the front panel of the kit is shown below.

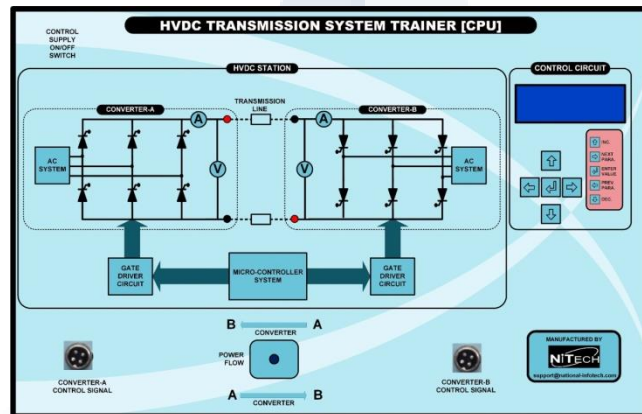
Converter Station:



Inverter Station:



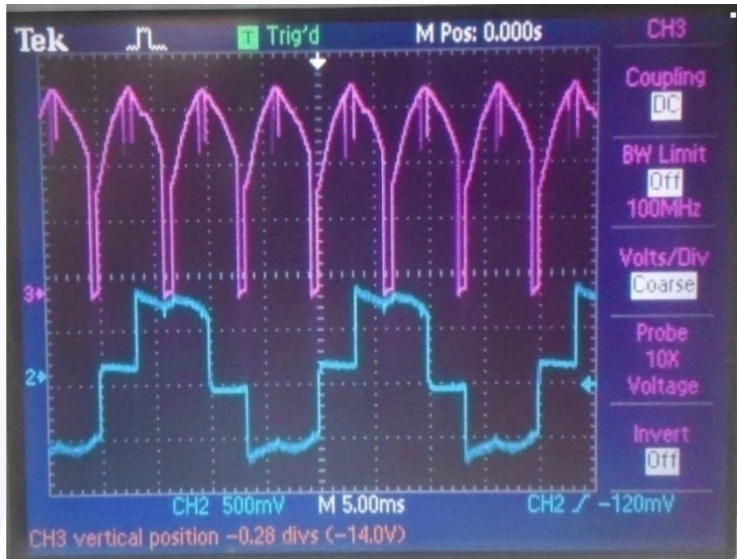
Control Unit:



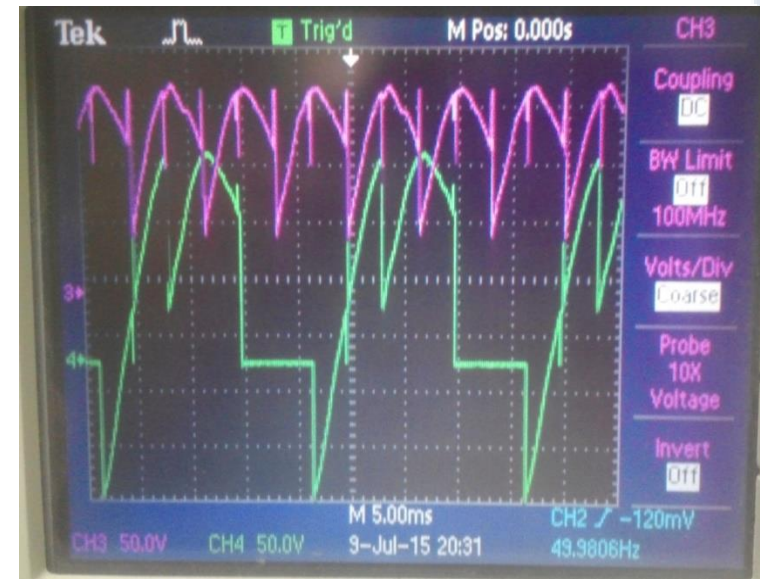
Detailed features and specifications are as listed below:

- ❖ Panel for demonstrating HVDC transmission system.
- ❖ Kit works directly with 415V, 50 Hz, three-phase power supply. Required step down transformer for generating 110 V, three-phase voltage is provided internally.
- ❖ Control circuit works with 230V, 50 Hz power supply and required low voltages are generated internally.
- ❖ Multi-function meter is provided in converter and inverter station for measuring three-phase line parameter like voltage, current, active power, reactive power etc.
- ❖ Meter for measuring converter and inverter side DC voltage and current.
- ❖ LCD display for displaying firing angles of converter and inverter.
- ❖ Bidirectional flow of power possible.
- ❖ Observation of source current, device voltage and DC link voltage is possible.
- ❖ Principle of bipolar HVDC is fully demonstrated with this kit.
- ❖ MCBs are provided for protection.

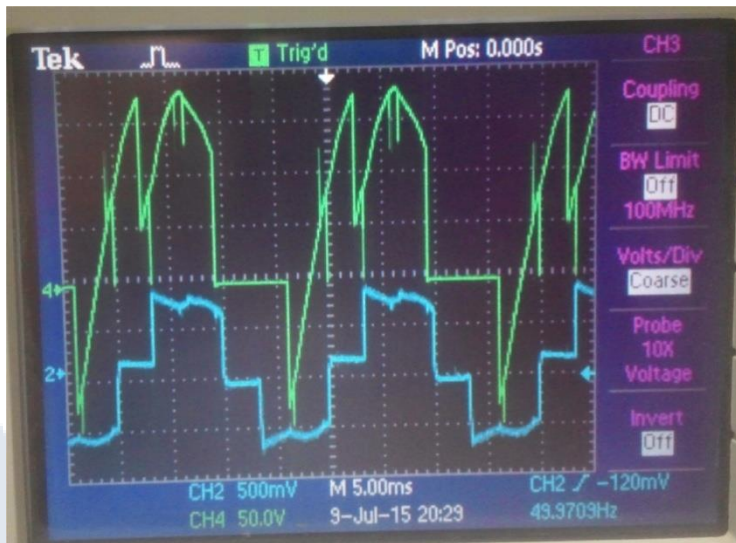
Typical Waveforms:



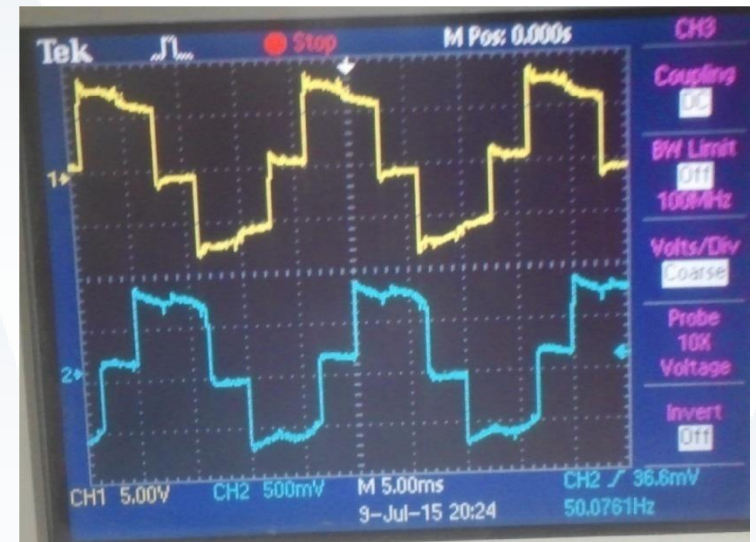
Waveforms of output voltage (Vdc) and input AC current of converter station (for Firing angle 30°)



Waveforms of output voltage (Vdc) and voltage across device of converter station (for Firing angle 15°)



Waveforms of voltage across device and input AC current of converter station (for Firing angle 15°)



Waveform of input AC current of converter station and inverter station (for Firing angle 15°)

NIAPS08 Instantaneous VAR Compensator (STATCOM)

This trainer kit is designed for demonstrating reactive power control using STATCOM.

Specification:

- ❖ 110 V, 50 Hz, Three phase supply,
- ❖ 500 VAR variable reactive load (leading and lagging),
- ❖ 1 kVA three phase STATCOM IGBT based power converter for compensation
- ❖ Multi-parameter for measuring supply voltage, current and other parameters.
- ❖ Control algorithm developed in Synchronous Reference Frame
- ❖ ARM Cortex M4 32-bit microcontroller based digital controller
- ❖ Intermediate stage test point observations using Two Digital to Analogue Converter (DACs)
- ❖ Different test points in control and power circuit

List of Experiments:

- ❖ Measurement of active and reactive power of different type of load.
- ❖ Compensation of reactive power with STATCOM operating in open loop.
- ❖ Compensation of reactive power with STATCOM operating in closed loop.

NIAPS09 Shunt Active Power Filter (SAPF)

Specification:

- ❖ 110V, 50 Hz, Three phase supply
- ❖ 500 VA harmonic producing load,
- ❖ 1 kVA three phase IGBT based power converter for compensation
- ❖ Multi-parameter for measuring supply voltage, current and other parameters.
- ❖ Control algorithm developed in Synchronous Reference Frame
- ❖ ARM Cortex M4 32-bit microcontroller based digital controller
- ❖ Intermediate stage test point observations using Two Digital to Analogue Converter (DACs)
- ❖ Different test points in control and power

List of Experiments:

- ❖ Measurement of voltage, current, active power, reactive power and source current THD of the load.
- ❖ Harmonic compensation using shunt active filter.
- ❖ Observation of source current, load current and compensator current different stage of compensation.

NIAPS10 VSC based FACTS Controller (STATCOM, SSSC and UPFC) with Transmission Line and Different Loading

VSC-based FACTS controllers with the following specifications -

- ❖ System voltage 120V, 50 Hz, three-phase provided through 415:120 V three-phase transformer
- ❖ Transmission line with three PI sections are constructed
- ❖ Three load banks (i) R load; (ii) R-L load and (iii) R-C load are provided for experimenting their effect on transmission line.
- ❖ Four stage load banks for experimenting variation of loading on transmission line.
- ❖ Maximum loading is up to 1 kVA.
- ❖ Three multi parameter energy meters are provided at sending end, receiving end and load end of the transmission line.
- ❖ Numbers of MCBs are provided for connecting and disconnecting different compensators.
- ❖ FACTS controller with shunt compensator (STATCOM), series compensator (SSSC) and shunt-series compensation (UPFC operation) is provided.
- ❖ 1 kVA IGBT based VSC with filter as shunt compensator.
- ❖ 1 kVA IGBT based VSC with filter and series injection transformer as series compensator.
- ❖ Control circuit designed using Synchronous Reference Frame (SRF) based control algorithms.
- ❖ Control algorithm are developed using ST Microelectronics ARM Cortex M4 microcontroller.
- ❖ Intermediate stage test point observations using two Digital to Analogue Converter (DACs)
- ❖ AC/DC voltages and currents sensing circuit and DC link voltmeter is provided.
- ❖ Many more than developed algorithms can be experimented.

- ❖ Programming using C language or MATLAB/Simulink environment.

List of Experiments:

- ❖ Study the Effect of Different Type of Loadings on Transmission Line.
- ❖ Compensation using Shunt Compensator in Closed Loop.
- ❖ Compensation using Shunt Compensator in Open Loop.
- ❖ Compensation using Series Compensator in Open Loop.
- ❖ Compensation using Series Compensator in Closed Loop.
- ❖ Compensation using Shunt-Series Combined Compensator.

